New LCA Theses

Enhancing the Application Efficiency of Life Cycle Assessment for Industrial Uses

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While the roots of life cycle management (LCM) are more than 25 years old and can be traced back to different sources (e.g. Royston 1979, Öko-Institut 1987) it has gained momentum in recent years, both from a scientific point of view as well as in regards to the implementation in industry (see Heinrich and Klöpffer 2002, Hunkeler et al. 2004, Jensen and Remmen 2004). The potential benefits of implementing life cycle approaches are generally accepted, though in regards to the level and scope of implementation LCM is still in its infancy. Central questions concern the measurement of the sustainability performance of products. Only if products and related measures can be assessed and analyzed, can progress or negative developments be reported and used for actual decision making and management purposes. Looking uniquely at the environmental dimension, life cycle assessment (LCA), the only internationally standardized environmental assessment method, is the primary and established tool for assessing the environmental performance of a good or service within LCM. However, the application of LCA is limited, because it is a rather sophisticated method, and the direct usage of the method and employment for decision making is absolutely non-trivial and needs expert support. In addition, the required effort can be quite high, which poses additional barriers for its application.

To address some of the aforementioned challenges and to enhance the application efficiency of LCA by making LCA more easily and rapidly usable with less resources and by using the LCA model as a basis for life cycle costing (LCC), the Ph.D. thesis focuses on the following issues:

The **Modular LCA** concept, based on foreground unit processes, is developed, where each module is essentially a gate-to-gate unit process, where energy generation, production of ancillaries, as well as recycling and waste-management processes are integrated. The life cycle impact assessment (LCIA) is conducted per such module and the LCA is build by aggregating the life cycle category indicator results of the modules. This approach facilitates the application of LCA to a large extent, specifically for cases where a fairly complete database exists. In addition, indirect impacts can be easily allocated to the foreground processes causing them, thus providing datasets that can also be directly employed for site-oriented environmental management activities (site-ecobalances).

For situations where sufficient datasets are not available, a **framework and specific methods with the aim of guiding the system boundary selection in regards to cut-offs** are elaborated. The concepts of (i) process specific cut-offs and (ii) baseline approximation based on input-output LCA are introduced.

(i) The work related to process specific cut-offs leads to the recommendation to employ cut-offs in the range of 4–5% (i.e. for instance that the production of inputs with a mass smaller than 4 to 5% of the process product can be neglected), if a coverage of 80% of the impacts is regarded as sufficient. This has been tested for cradle-to-gate assessments of the production of different materials and for an automotive component.

(ii) The idea to use input-output LCA results as a baseline for estimating the overall impact of an (unknown) product system and thus for defining cut-offs, in the context of industrial decision-support, however, seems to be less promising. For one, the sectors of input-output analysis and therefore the unit processes of input-output LCA are usually not sufficiently specific to differentiate between alternatives within one sector. Secondly, one cannot find a systematic trend relating results of input-output LCA to (process) LCA. Specifically, price variations of commodities over time (market fluctuations) and even more due to different product characteristics (different products or commodities produced by one sector), in addition to problems of considering impacts from imports and exports, lead to high variations. These variations do not allow to derive general recommendations for using input-output LCA as a baseline for approximation.

In addition to dealing with the question on how the use of LCA can be facilitated by improved methodological procedures of LCA itself, this thesis also examines the economic pillar of LCM and introduces a **life cycle costing (LCC) method that is based on the life cycle inventory of an LCA**. This use of LCA models for LCC is the first consistent attempt to cover the economic dimension of sustainability in parallel to the environmental assessment. This combination of approaches has proven to be very useful and valid, also demonstrated in case studies from the automotive sector and for wastewater treatment. LCC based on the life cycle inventory of an LCA is a path that should be followed further, since the additional effort needed for an LCC, once the product system model is available, is minimal.

The thesis (Rebitzer 2005) is available directly from the author or at: http://library.epfl.ch/theses/?nr=3307

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